DEPARTMENT OF ZOOLOGY
(Three/Four Year Undergraduate Programme)
SYLLABUS
B.Sc. - Specialization (Zoology)
(Semester Scheme)
Choice-Based Credit System (CBCS)
[As Per the National Education Policy (NEP) – 2020]

B. Sc. (Zoology) Semester I & II
Subject: Zoology
Session 2025-onwards

Name of the Affiliating University	**University of Rajasthan, Jaipur**
Name of Faculty	**Science**
Name of Discipline	**ZOOLOGY**
Type of Discipline	**Major**
A list of programmes offered as a Minor Discipline	**Biotechnology** **Botany** **Chemistry** **Microbiology**
Offered to Non-Collegiate Students	**No**

SEMESTER-WISE PAPER TITLES WITH DETAILS

Examination Scheme (CBCS – NEP 2020)

- **End of Semester Exam (EoSE)**: 70 Marks (3 hrs)
- **Continuous Internal Assessment (CIA)**: 30 Marks
- **Maximum Marks (Each Theory Paper)**: 100 Marks
- **Practical Examination**: 50 Marks (20 Internal + 30 External)
- **Grand Total Per Semester**: 150 Marks (Theory + Practical)
- **Credits**:
  - 1 Credit = 25 Marks
  - Theory Classes: 3 hrs/week per paper
  - Practical Classes: 4 hrs/week per lab

Pattern of Theory Question Papers:

- **Part A**: 7 Very Short Questions (out of 10) × 2 marks = 14 Marks
- **Part B**: 4 Questions (1 from each unit with internal choice) × 14 marks = 56 Marks
- **Total (EoSE)** = 70 Marks

Type of Examination	**Course Code and Nomenclature**	**Duration of Examination**	**Maximum Marks**	**Minimum Marks**
Theory (EoSE)	End of Semester Exam (Each Paper)	3 Hrs	70 Marks	28 Marks
Theory (CIA)	Continuous Internal Assessment (Each Paper)	1 Hr	30 Marks	12 Marks
Theory (Total)	Each Theory Paper	–	100 Marks	40 Marks
Practical	Practical Examination (Internal + External)	Internal – 1 Hr External – 3 Hrs	20 Marks 30 Marks 50 Marks	20 Marks
Overall Semester	Theory + Practical	–	150 Marks	60 Marks

EXAMINATION SCHEME FOR REGULAR STUDENTS

***** CIA: Continuous Internal Assessment EoSE: End of Semester Examination

Theory Question Paper Scheme:

The question paper will consist of **two** parts **A** & **B**.
PART-A: 14 Marks: Part A will be compulsory having 10 very short answer-type questions (with a limit of 20 words) of two marks each out of which 7 questions will be attempted.
PART-B: 56 Marks: Part B of the question paper shall be divided into four units comprising question numbers 2-5. There will be one question from each unit with internal choice. Each question will carry 14 marks.

Practical Question Paper Scheme:

Regular Students: For regular students, the question paper will be of **30 Marks**, with an additional **20 Marks** allocated for internal assessment.
NC/Ex-Students: The practical examination will have a total of 50 marks for non-collegiate students or ex-students.
The detailed marking scheme can be found in the practical exam syllabus for the respective paper.

SYLLABUS

UG0812-ZOO-51T-151-Lower Invertebrates I-Semester - Zoology

Seme	Code of the Course	Title of the Course/Paper				NHEQF Level	Credits
I	25ZOO-5151T 25ZOO-5151P	Lower Invertebrates Practical based on Lower Invertebrates				5	6
Level	**Type of the Course**	**Credit Distribution**			**Offe**	**Course Delivery Method**	
		The	**Practica**	**Tot**			
5	Major	4	2	6	No	Lectures and Practical	
List of Programme Codes in which Offered as Minor Discipline		NA					
Prerequisites		XII Pass					
Objectives of the Course:		By the end of this course, students will be able to: 1. To provide a comprehensive understanding of the phylogenetic relationships and classification of Protozoa, Porifera, Coelenterata, Platyhelminthes, and Aschelminthes up to the class level. 2. To study the detailed characteristics, including locomotion, nutrition, and reproduction, of representative species like *Paramecium*, *Amoeba*, *Plasmodium*, *Sycon*, *Obelia*, *Hydra*, *Taenia*, *Ascaris*, and *Fasciola*. 3. To explore the functional biology of simple organisms, focusing on their structural and reproductive strategies. 4. To discuss the ecological and economic importance of the studied phyla, especially in understanding their roles in ecosystems and their relevance to human activities.					

	5. To conduct a comparative study of the life cycles of parasitic and free-living organisms, enhancing the understanding of their adaptive strategies. 6. To understand the concept of metagenesis in coelenterates, particularly through the study of Obelia. 7. To link theoretical knowledge with practical applications, helping students appreciate the relevance of these phyla in applied zoology.

Detailed Syllabus
25ZOO-5151T-Lower Invertebrates

Unit-I

Principles of T axonomy:
International Code of Zoological Nomenclature;
Concept of Five Kingdom System **3 Lectures**
Basis of Classification: Symmetry, Coelom, Segmentation, Embryogeny **4 Lectures**
Levels of Organization, Invertebrate Versus Vertebrate (Comparison). **2 Lectures**
Phylum: Protozoa
Salient Features and Classification of Protozoa Up to Classes. 2 **Lectures**
Nutrition, Locomotion and Reproduction in Protozoa 6 Lectures

Unit-II

Phylum: Porifera
Salient Features and Classification of Porifera Up to Classes. **2 Lectures**
Sycon (Salient Features, Nutrition, Reproduction). 3 **Lectures**
Evolution of the Canal System of Sponges. 2 **Lectures**
Types and Development of Spicules in Porifera 2 **Lectures**

Unit-III

Phylum: Coelenterata
Salient features and classification of Cnidaria and Ctenophora up to Class **3 Lectures**
Obelia (Salient Features, Nutrition, Reproduction, Metagenesis) **4 Lectures**
Polymorphism in Coelenterata **2 Lectures**
Coral, Coral Reefs and Their Economic Importance **3 Lectures**

Unit-IV Phylum: Platyhelminthes and Aschelminths

Salient Features and Classification of Platyhelminthes and Aschelminths (up to Classes) **2 Lectures**
Fasciola (External features, Nutrition, Excretion, Nervous, Reproduction and Life Cycle 4 **Lectures**
Taenia (External features, Excretion, Nervous, Reproduction and Life Cycle) 3 **Lectures**
Ascaris (External features, Reproduction and Life Cycle) **3 Lectures**
Parasitic Adaptations in Helminths **3 Lectures**

Suggested Books and References –

1. Barnes, R. (1981). Invertebrate Zoology. W.B. Saunders Co
2. Barrington, E.W.J. (1969). Invertebrate Structure and Function. ELBS
3. Barradaile L.A. & Potts F.A. The Invertebrate
4. Jordan, E. L. & Verma, P.S. Invertebrate Zoology. S. Chand & Co.
5. Kotpal, Agrawal &Khetrapal. Modern Textbook of Zoology – Invertebrates.
6. Puranik P.G. & Thakur R.S. Invertebrate Zoology
7. Majupuria T.C. Invertebrate Zoology

8. Dhami & Dhami. Invertebrate Zoology
9. Parker &Hashwell, Textbook of Zoology Vol. I (Invertebrates) A.Z.T.B.S. Publishers
10. R.L. Kotpal – Phylum Protozoa to Echinodermata (series), Rastogi and Publication, Meerut
11. Vidyarthi – Textbook of Zoology, Agrasia Publishers, Agra
12. Marshal & Williams. Textbook of Zoology.
13. Boolotin & Stiles. College Zoology. MacMillan

Course Learning Outcomes –

After successful completion of the course:

- Students will be able to classify Protozoa up to the class level and describe their salient features, understanding the diversity within this phylum.
- Students will gain detailed knowledge of *Paramecium*, *Amoeba*, and *Plasmodium*, including their locomotion, nutrition, and reproduction processes.
- Students will be able to classify Porifera up to the class level, describe the salient features, and understand the canal system of sponges.
- Students will be able to classify Cnidaria and Ctenophora up to the class level and understand their unique features, including metagenesis in Obelia.
- Students will develop a solid understanding of Platyhelminthes and Aschelminthes, including their classification, external features, and life cycles, with emphasis on species like *Taenia*, *Ascaris*, and *Fasciola*.
- Students will be able to connect theoretical knowledge with practical applications, appreciating the relevance of the studied phyla in applied zoology.
- Students will be able to compare the life cycles and adaptations of parasitic and free- living organisms, enhancing their analytical skills in understanding evolutionary strategies.

25ZOO-5151P-Practical based on Lower Invertebrates

Duration: 4 Hrs
Max. Marks: 20+30 Marks

Microscopic Techniques:
Organization and working of optical microscopes:
Dissecting and Compound Microscope;
General methods of microscopical permanent preparations
Fixatives and Preservatives: Formalin, Bouin's Fluid
Borax carmine, Acetocarmine, Acetoorcein, Haematoxylin, Eosin Common Reagents: Normal saline, Ringer's solution, Acid water, Acid alcohol, Mayer's egg albumin
Study of museum specimens (Classification of animals up to orders):
Protozoa: Euglena, Elphidium (Polystomella), Foraminiferous shell, Monocystis, Opalina, Paramecium, Paramecium showing Binary fission, Paramecium Conjugation, Balantidium, Nyctotherus, Vorticella
Porifera: Leucosolenia, Sycon, Hyalonema, Euplectella, Spongilla
Coelenterata: Obelia Colony & Medusa, Millepora, Physalia, Vellela, Aurelia, Alcyonium, Gorgonia, Pennatula, Metridium, Stone Corals
Platyhelminthes: Planaria, Fasciola, Taenia
Aschelminthes: Ascaris, Dracunculus, Ancylostoma, Wuchereria
Annelida: Neanthes (Nereis), Heteronereis, Polynoe, Chaetopterus, Arenicola, Pheretima (Earthworm), Aphrodite, Pontobdella,Clespine (Glossiphonia), Hirudinaria (H.granulosa), Polygordius
Study of Permanent Slides:
Porifera: Sponge Gemmules, Sponge Spicules, V.S. Sycon, T.S. Sycon
Coelenterata: *Obelia* Medusa, *Obelia* Colony
Platyhelminthes: Miracidium, Sporocyst, Redia, and Cercaria, Metacercarial larvae of *Fasciola*, Hexacanth and Oncosphere Larvae of *Taenia solium*, Scolex of *Taenia*, Mature and Gravid Proglottids of *Taenia solium*
Annelida: *Parapodia of Nereis; Parapodia of Heteronereis*

Audio-visual Demonstration of External Features and Anatomy:

Major:
Earthworm: External Features, Digestive, Nervous, and Reproductive Systems
Leech: External Features, Digestive, Nervous, and Reproductive Systems
Minor:
Mounting: Permanent Slide Preparation of Parapodia (Neries), Parapodia (Hetroneris), Spermatheca
Mounting:
Paramecium, Euglena, Spicules, Spongin Fibers, and Gemmules of Sponge,
Obelia Colony, Medusa

Visit
A Visit to Any Natural Habitat (Aquatic/ Terrestrial) For Collecting and Studying the Natural Behaviour of Invertebrates

Scheme of Practical Examination and Distribution of Marks

S.N.	Exercise/Practical	Regular	Ex. Students
1.	Major Exercise	**3**	**12**
2.	Minor Exercise	**2**	**6**
3.	Minor Exercise	**3**	**6**
4.	Identification and comments on Spots (1 to 6)	**12**	**16**
5.	Viva Voce	**5**	**10**
6.	Class Record	**5**	
	Total	**30 + 20*=50**	**50**

*Internal marks for regular students only

Note:

1. With reference to microscopic slides, in case of non-availability, the exercise should be substituted with diagrams / photographs.
2. Candidates must keep a record of all work done in the practical class and submit the same for inspection at the time of the practical examination.
3. The candidates may be asked to write detailed methodology wherever necessary and separate marks may be allocated for the same.
4. Mounting material for permanent preparations would be as per the syllabus or as available through collection.
5. It should be ensured that animals used in the practical exercises are not covered under the wild life act 1972 and amendments made subsequently.

25ZOO-5152T- Higher Invertebrates I-Semester - Zoology

Semester	Code of the Course	Title of the Course/Paper				NHE	Cred
I	**25ZOO-5152T 25ZOO-5152P**	Higher Invertebrates Practical based on Higher Invertebrates				5	6
Level of Course	**Type of the Course**	**Credit Distribution**			**Offe**	**Course Delivery Method**	
		The	**Practical**	**Tot**			
5	Major	4	2	6	No	Lectures and Practical	
List of Programme Codes in which Offered as Minor Discipline		NA					
Prerequisites		XII Pass					
Objectives of the Course:		By the end of this course, students will be able to: 1. Understand the general characteristics and classification of Annelida, Arthropoda, Mollusca, and Echinodermata up to the class level with examples. 2. Learn about the evolution of coelom and metamerism in Annelida. 3. Explore the nutrition, excretion, and respiration processes in Annelida. 4. Study the anatomy and developmental stages of Nereis, including its external characters, morphology, and systems. 5. Examine the social behaviours and life cycles in arthropods, particularly in bees and termites.					

Detailed Syllabus
25ZOO-5152T- Higher Invertebrates

Unit-I

Phylum: Annelida

General Characters and Outline Classification Up to Classes with Examples.	**2 Lectures**
Nereis (External Features, Morphology, Digestive, Excretory, Nervous System, Development & Trochophore Larva)	**5 Lectures**
Evolution of Coelom and Metamerism	**2 Lectures**
Nutrition, Excretion, And Respiration in Annelida	**6 Lectures**

Unit-II

Phylum: Arthropoda

General Characters and Outline Classification Up to Classes with Examples.	**2 Lectures**
Prawn (External characters, Morphology, Skeletal, Digestive, Respiratory, Nervous, Circulatory, Excretory & Reproductive Systems)	**6 Lectures**
Metamorphosis in Insects, Types of Metamorphosis	**3 Lectures**
Mouth Parts in Arthropoda; Larval Forms in Crustacea	**3 Lectures**

Unit-III

Phylum: Mollusca

General characters and outline classification up to classes with examples.	**3 Lectures**
Pila (External Characters, Skeletal System, Digestive System, Respiration, Nervous System, Circulatory, and Excretion)	**8 Lectures**
Larval Forms in Mollusca: Velliger, Glochidium	**2 Lectures**

Unit-IV

Phylum: Echinodermata and Hemichordata

General Characters and Outline Classification Up to Classes with Examples.	**3 Lectures**
Asterias (External Characters, Water Vascular System, Digestive System, & Reproductive Systems	**7 Lectures**
Water-Vascular System in Echinodermata	**2 Lectures**
Larval Forms in Echinodermata	**3 Lectures**
Balanoglossus: Salient Features and Affinities	

Suggested Books and References –

Systematics (Animal Taxonomy)

1. Dalela, R.C. & Sharma, R.K. (1976). *Animal Taxonomy and Museology*. Jai Prakash Nath.
2. Kapoor, V.C. (1988). *Theory and Practicals of Animal Taxonomy*. Oxford & IBH.
3. Kapoor, V.C. (2011). *Theory and Practice of Animal Taxonomy* (Relevant sections on Invertebrate classification). Oxford & IBH Publishing.
4. Simpson, G.G. (1962). *Principles of Animal Taxonomy*. Oxford.
5. Roy Mahoney (1966). *Laboratory Techniques in Zoology*. Butterworths.
6. Mayer, E. & Ashlock, P.D. (1991). *Principles of Systematic Zoology*. McGraw Hill.

Non-Chordates

1. Ruppert, E.E., Fox, R.S., & Barnes, R.D. (2004/2006). *Invertebrate Zoology: A Functional Evolutionary Approach* (7th/8th Ed.). Brooks/Cole, Cengage Learning / Holt Saunders International.
2. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W., & Spicer, J.I. (2002). *The Invertebrates* (3rd Ed.). Blackwell Science.
3. Barrington, E.J.W. (1979). *Invertebrate Structure & Function* (2nd Ed.). ELBS & Nelson.
4. Barradaile, L.A. & Potts, F.A. *The Invertebrate*.
5. Parker, T.J. & Haswell, W.A. (2005). *Textbook of Zoology, Vol. I (Invertebrates)*. Macmillan / A.Z.T.B.S. Publishers.
6. Brusca, R.C. & Brusca, G.J. (2003). *Invertebrates* (2nd Ed.). Sinauer Associates.
7. Anderson, D.T. (2001). *Invertebrate Zoology*. Oxford University Press.
8. Majupuria, T.C. *Invertebrate Zoology*.
9. Marshall & Williams. *Textbook of Zoology*.
10. Meglitsch, P.A. & Schram, F.R. (1991). *Invertebrate Zoology* (3rd Ed.). Oxford University Press.
11. Pechenik, J.A. (2022). *Biology of the Invertebrates* (8th Ed.). McGraw-Hill Education.
12. Hickman, C.P., Roberts, L.S., Keen, S.L., Larson, A., Eisenhour, D.J. (2020). *Integrated Principles of Zoology* (18th Ed.). McGraw-Hill.
13. Campbell, N.A. & Reece, J.B. (2005). *Biology* (7th Ed.). Pearson.
14. Miller, S.A. & Harley, J.P. (2006). *Zoology* (7th Ed.). McGraw-Hill Education.
15. Boolotian, R.A. & Stiles, K.A. (1981). *College Zoology* (10th Ed.). Macmillan.
16. Jordan, E.L. & Verma, P.S. *Invertebrate Zoology*. S. Chand & Co.
17. Kotpal, R.L. (Phylum Series: Protozoa to Echinodermata). Rastogi Publications, Meerut.
18. Kotpal, Agarwal & Khetrapal. *Modern Textbook of Zoology – Invertebrates*.
19. Puranik, P.G. & Thakur, R.S. *Invertebrate Zoology*.
20. Dhami, P.S. & Dhami, J.K. *Invertebrate Zoology*.
21. Vidyarthi. *Textbook of Zoology*. Agrasia Publishers, Agra.
22. Nigam, H.C. (1997). *Biology of Non-Chordates*. S. Chand.
23. Arora, M.P. & Malhotra, P. (2008). *Invertebrate Zoology for Degree Students*. Himalaya Publishing House, Mumbai.
24. Tandon, K.K. & Sharma, P.D. (2007). *A Textbook of Invertebrate Zoology*. Vikas Publishing House, New Delhi.
25. Prasad, S.N. & Bharadwaj, G.P. (2021). *A Textbook of Invertebrate Zoology*. Vikas Publishing House, New Delhi.
26. Ekambaranatha Ayyar, C.N. & Ananthakrishnan, T.N. (2002). *Manual of Zoology, Vol. I (Invertebrates)*. S. Viswanathan Pvt. Ltd., Chennai.
27. Verma, P.S. & Agarwal, V.K. (2015). *Cell Biology, Genetics, Molecular Biology, Evolution and Ecology* (Selected invertebrate topics). S. Chand & Co.

Practical Zoology (Invertebrates)

1. Verma, P.S. *A Manual of Practical Zoology: Invertebrates*. S. Chand & Co.
2. Lal, S.S. (9th Ed.). *Practical Zoology: Invertebrates*. Rastogi Publications, Meerut & Distributors, New Delhi.
3. Roy Mahoney (1966). *Laboratory Techniques in Zoology*. Butterworths.

Online Tools and Web Resources

1. SWAYAM (MHRD Portal) – Government of India's online education platform. SWAYAM Portal

2. Animal Diversity (SWAYAM Course) – Online course on animal diversity. Animal Diversity Course
3. Advances in Animal Diversity, Systematics and Evolution (SWAYAM Course) Advances in Animal Diversity, Systematics and Evolution
4. e-PG Pathshala

Course learning outcomes –

- Students will be able to classify Annelida, Arthropoda, Mollusca, and Echinodermata up to the class level.
- Students will understand the evolution and significance of coelom and metamerism in Annelida.
- Students will describe the anatomy, nutrition, excretion, and respiration mechanisms in Annelida, with a focus on Nereis.
- Students will explain the external and internal structures of Arthropoda, particularly in prawns, and understand the types of metamorphosis in insects.
- Students will understand the anatomical features and physiological systems of Mollusca, with a focus on Pila, and explain the process of pearl formation in bivalves.
- Students will be able to analyze the structure and function of the water-vascular system in Echinodermata.

25ZOO-5152P- Practical based on Higher Invertebrates

Duration: 4 Hrs

Max. Marks: 20+30 Marks

Study of Museum Specimens (Classification of Animals Up To Orders)

Arthropoda:

Peripatus, Lepus, Balanus, Sacculina, Squilla, Palemon, Eupagurus (hermit Crab), *Carcinus* (Crab), *Scolopendra, Julus*, Scorpion, Spider, *Limulus*, *Schistocerca*/*Locusta*, Dragonfly, Praying mantis, Queen Termite, *Cimex*, Moth/ Butterfly

Mollusca:

Chiton, Dentalium, Cypraea, Pila, Aplysia, Mytilus, Pinctada, Loligo, Sepia, Octopus, Nautilus

Echinodermata:

Antedon, Asterias, Ophiothrix, Echinus, Cucumaria, Holothuria

Study of Permanent Slides:

Arthropoda: Crustacean Larvae - Nauplius, Zoea, Metazoea, Megalopa, Mysis
Mollusca: Veliger and Glochidium larvae, T.S. of *Unio* Shell
Echinodermata: T.S. of arm of starfish
Hemichordata: *Balanoglossus* through collar and proboscis

Audio-visual Demonstration of External Features and Anatomy:

Major:
Prawn: External Features, Appendages, Digestive, Nervous, and Reproductive System
Pila: External Features, Nervous System
Minor:
Mounting: *Daphnia*; Prawn (Hastate Plate, Statocyst) Pila (Gill lamella, Osphradium, Radula)
Field Work

1. Observation And Collection of Aquatic Invertebrates from a Pond
2. Insect Diversity Study in a Local Area (Garden/ Field)
3. Study Of Soil-Dwelling Non-Chordates with Special Focus on Earthworms:

(Collection and in-Lab Work, External Features, Vermicomposting Demonstration, Experimental Identification of Soil Texture)

Scheme of Practical Examination and Distribution of Marks

S. N.	Exercise/Practical	Regular	Ex. Students
1.	Major Exercise	3	12
2.	Minor Exercise	2	6
3.	Minor Exercise	3	6
4.	Identification and comments on Spots (1 to 6)	12	16
5.	Viva Voce	5	10
6.	Class Record	5	

	Total	**30+20*=50**	**50**

*Internal marks for regular students only

Note:

1. With reference to microscopic slides, in case of non-availability, the exercise should be substituted with diagrams / photographs.
2. Candidates must keep a record of all work done in the practical class and submit the same for inspection at the time of the practical examination.
3. The candidates may be asked to write detailed methodology wherever necessary and separate marks may be allocated for the same.
4. Mounting material for permanent preparations would be as per the syllabus or as available through collection.
5. It should be ensured that animals used in the practical exercises are not covered under the wild life act 1972 and amendments made subsequently.

25ZOO-5153T Chordate Biology Semester - II

Sem	Code of the Course	Title of the Course/Paper	NHE	Cre
II	25ZOO-5153T 25ZOO-5153P	Chordate Biology Practical based on Chordate Biology	5	6

Level	Type of the Course	Credit Distribution			Offered to NC	Course Delivery
		The	Practic	Tot		
5	Major	4	2	6	No	Lectures and Practic

List of Programme Codes in which Offered as Minor Discipline	NA
Prerequisites	I Semester
Objectives of the Course:	1. To understand the general characteristics and classification of chordates, including the origin theories and evolutionary affinities of protochordates and other related groups. 2. To gain knowledge about the anatomy, larval forms, and metamorphosis of protochordates, particularly Urochordata and Cephalochordata. 3. To explore the classification, characteristics, and adaptations of various vertebrate classes such as Agnatha, Pisces, Amphibia, Reptilia, Aves, and Mammals. 4. To study the evolutionary adaptations, including parental care, migration, and osmoregulation, in fishes, amphibians, reptiles, birds, and mammals. 5. To examine the specialized features and evolutionary significance of various groups, such as the development of cleidoic eggs in reptiles, flight adaptations in birds, and dentition in mammals.

Detailed Syllabus
25ZOO-5153T -Chordate Biology

Unit-I

Chordata **15 Lectures**

- General characteristics and outline classification of Chordata
- Dipleurula and the echinoderm theory of origin of chordates
- **Protochordata:**
  - General Characteristics of Urochordata and Cephalochordata
  - Habit, Habitat, External Features and Anatomy of *Herdmania a*nd *Branchiostoma*
  - (Excluding Development).
  - Study of larval form in protochordates; Ascidian tadpole larva and its metamorphosis
  - Affinities of Hemichordata, Urochordata and Cephalochordata

Unit-II

Lower Vertebrates:

Agnatha: **5 Lectures**

- General characteristics and classification of cyclostomes up to classes
- Habit, habitat and salient features of Petromyzon and its Ammocoete larva

Pisces: **14 lectures**

- General characteristics and classification up to order
- Parental care and migration in fishes
- Aquatic adaptation in fishes; osmoregulation in fishes
- Accessory respiratory organs in Pisces
- Different types of scales and fins of Pisces, theories of origin of fins
- Evolutionary significance of Dipnoi

Unit-III

Higher Vertebrates:

Amphibia: **5 Lectures**

- General characteristics and classification up to orders
- Neoteny
- Parental care in Amphibians

Reptilia: **8 Lectures**

- General characteristics and classification up to orders
- Evolution of cleidoic Eggs
- Reptilian Skull types
- Identification of Poisonous and Non-Poisonous Snakes
- Poison Apparatus and Biting mechanism in snakes

Unit-IV

Higher Vertebrates:

Aves: **8 Lectures**

- General characteristics and classification up to orders
- *Archaeopteryx* - A Connecting Link
- Types of Feathers
- Flight Adaptations and Migration in Birds

Mammals: **8 Lectures**

- General characteristics and classification up to orders
- Affinities of Prototheria
- Dentition in mammals
- Adaptive radiation in mammals

Suggested Books and References –

1. **Kotpal, R. L.** (2016). *Modern Textbook of Zoology – Vertebrates*. Rastogi Publications, Meerut.
2. **Young, J. Z.** (2004). *The Life of Vertebrates* (3rd ed.). Oxford University Press.
3. **Tiwari, S. K.** (2006). *Fundamentals of World Zoogeography*. Sarup & Sons.
4. **Pough, H.** (2007). *Vertebrate Life* (8th ed.). Pearson International.
5. **Hall, B. K., & Hallgrimsson, B.** (2008). *Strickberger's Evolution* (4th ed.). Jones and Bartlett Publishers Inc.
6. **Hickman, C. P., Roberts, L. S., Keen, S., Larson, A., I'Anson, H., & Isenhour, D. J.** (2008). *Integrated Principles of Zoology* (14th ed.). McGraw-Hill Publications.
7. **Verma, P. S., & Srivastava, P. C.** (2011). *Advanced Practical Zoology*. S. Chand Publications, New Delhi.
8. **Romer, A. S., & Parsons, T. S.** (1986). *The Vertebrate Body* (6th ed.). CBS College Publishing.
9. **Kent, G. C., & Carr, R. K.** (2001). *Comparative Anatomy of the Vertebrates* (9th ed.). McGraw-Hill Education.
10. **Colbert, E. H., & Morales, M.** (2001). *Evolution of the Vertebrates: A History of the Backboned Animals through Time* (5th ed.). John Wiley & Sons.
11. **Walker, W. F., & Homberger, D. G.** (1998). *Vertebrate Dissection* (8th ed.). Brooks/Cole, Cengage Learning.
12. **Saxena, R. K., & Saxena, S.** (2015). *Vertebrate Zoology*. Viva Books Pvt. Ltd., New Delhi.
13. **Ekambaranatha Ayyar, C. N., & Ananthakrishnan, T. N.** (2002). *Manual of Zoology, Vol. 2 (Chordates)*. S. Viswanathan (Printers & Publishers) Pvt. Ltd., Chennai.
14. **Jaiswal, P. L.** (2016). *Chordate Zoology*. Himalaya Publishing House, Mumbai.
15. **Khanna, D. R., & Yadav, P. R.** (2013). *Biology of Chordates*. Discovery Publishing House, New Delhi.
16. **Saxena, R. K., & Gupta, R. C.** (2011). *Practical Zoology – Chordates*. Viva Books Pvt. Ltd., New Delhi.
17. **Rao, C. V.** (2010). *Vertebrates: Comparative Anatomy, Function and Evolution*. Narosa Publishing House, New Delhi.

Practical Books:

1. Ekambaranatha Ayyar, C. N., & Ananthakrishnan, T. N. – *Manual of Zoology, Vol. 2 (Chordates)*, S. Viswanathan (Printers & Publishers) Pvt. Ltd., Chennai.
2. Kotpal, R. L. – *Modern Textbook of Zoology – Vertebrates*, Rastogi Publications, Meerut.
3. Verma, P. S., & Agarwal, V. K. – *Cell Biology, Genetics, Molecular Biology, Evolution and Ecology*, S. Chand Publications, New Delhi.

Suggested E-Resources –

1. https://www.fisheries.noaa.gov/educational-resources/fish-anatomy-interactive
2. https://www.khanacademy.org/science/health-and-medicine/histology/muscle- tissue/v/muscle-tissue
3. http://www.pathologyoutlines.com/topic/hematologybloodsmear.html
4. https://en.wikipedia.org/wiki/Lancelet
5. https://www.fishbase.de/
6. https://animaldiversity.org/

Course Learning Outcome:

- Students will be able to classify chordates and understand their general characteristics, including their evolutionary origins.
- Students will gain knowledge of the anatomy and life cycle of protochordates, with a focus on Urochordata and Cephalochordata.
- Students will develop an understanding of the classification and unique adaptations of vertebrates such as cyclostomes, fishes, amphibians, reptiles, birds, and mammals.
- Students will learn about the evolutionary significance of various adaptations in vertebrates, including osmoregulation in fishes, neoteny in amphibians, and flight adaptations in birds.
- Students will be able to identify and differentiate between poisonous and non-poisonous snakes and understand the mechanisms of their venom apparatus.
- Students will understand the evolutionary links and specialized features of vertebrates, such as the transition from reptiles to birds and adaptive radiation in mammals

25ZOO-5153P-156-Practical based on Chordate Biology

Duration: 4 Hrs

Max. Marks: 20+30 Marks

Herdmania: G**eneral anatomy, alimentary canal and reproductive system**

Permanent Slide Preparations:

1. **S**picule**s** and pharyngeal gill of Herdmania
2. Scales and Hair: Examination of different types of scales and hairs through permanent slide preparations.
3. Amphioxus: Oral hood
4. Different types of feathers in birds

Study of permanent slides:

Amphioxus and Larvae:

Whole mounts and transverse sections (T.S.) of various regions of Amphioxus **(through** oral hood, **pharynx and caudal regions); T.S. of** velum **and** pharyngeal wall**;** tadpole larva of Ascidia

Other Marine Organisms:

Whole mounts of marine organisms Salpa, Doliolum, and Oikopleura

Study of museum specimen:

Early Chordates and Fishes:

Ascidia, Ciona, Botryllus, Ammocoete larva, Petromyzon, Myxine or Bdellostoma,

Fishes:

Zygaena (*Sphyrna*), *Torpedo*, *Chimaera*, *Acipenser*, *Amia*, *Lepidosteus*, *Labeo*, *Clarias*, *Anguilla*, *Hippocampus*, *Exocoetus*, *Echeneis*, *Pleuronectes*, *Protopterus*

Amphibians:

Ichthyophis or blind- worm, *Proteus*, *Ambystoma*, *Axolotl*, *Siren*, *Alytes*, *Hyla*

Reptiles:

Testudo, *Chelone*, Fresh Water Tortoise, *Sphenodon*, *Hemidactylus*, *Phrynosoma*, *Draco*, *Chameleon*, *Eryx*, *Hydrophis*, *Naja*, *Viper*, *Crocodylus*, Alligator

Birds:

Archaeopteryx, Any running bird, *Pavo cristatus*, *Choriotis nigriceps*

Mammals:

Ornithorhynchus, *Tachyglossus*, *Didelphis*, *Macropus*, *Loris*, Scaly Anteater

Scheme of Practical Examination and Distribution of Marks

S.No.	Exercise/Practical	Regular	Ex. Students
1.	Major Exercise	**3**	**12**
2.	Minor Exercise	**2**	**6**
3.	Minor Exercise	**3**	**6**
4.	Identification and comments on Spots (1 to 6)	**12**	**16**
5.	Viva Voce	**5**	**10**
6.	Class Record	**5**	
	Total	**30+ 20*** **=50**	**50**

*Internal marks for regular students only

Note:

1. With reference to microscopic slides, in case of non-availability, the exercise should be substituted with diagrams / photographs.
2. Candidates must keep a record of all work done in the practical class and submit the same for inspection at the time of the practical examination.
3. The candidates may be asked to write detailed methodology wherever necessary and separate marks may be allocated for the same.
4. Mounting material for permanent preparations would be as per the syllabus or as available through collection.
5. It should be ensured that animals used in the practical exercises are not covered under the wild life act 1972 and amendments made subsequently.

25ZOO-5154T- Comparative Anatomy & Developmental Biology of Vertebrates
II-Semester - Zoology

Semester	Code of the Course	Title of the Course/Paper	NHE	Cre
II	**25ZOO-5154T** **25ZOO-5154T**	Comparative Anatomy & Developmental Biology of Vertebrates Practical based on Comparative Anatomy & Developmental Biology of Vertebrates	5	6

Level of Course	Type of the Course	Credit Distribution			Offered to NC	Course Delivery
		Theory	Pr	Tot		
5	Major	4	2	6	No	Lectures and Practic

List of Programme Codes in which Offered as Minor Discipline	NA
Prerequisites	I Semester
Objectives of the Course:	1. The course offers a complete understanding about anatomy of vertebrate animals. 2. Thorough understanding of essential and evolutionary aspects of comparative anatomy will be developed through pictorial presentation of different anatomical details. 3. The course will also provide a glimpse of scope and historical background of developmental biology to the students, impart knowledge regarding basic concepts of differentiation, morphogenesis and pattern formation and insight into IVF, stem cells and cloning. 4. Detailed understanding of essential events of developmental biology will be imparted through proper explanation of gametogenesis, and stages of embryonic development and foetal formation.

Detailed Syllabus
Comparative Anatomy & Developmental Biology of Vertebrates

Unit – I

Comparative anatomy of mentioned vertebrates:
Pisces (Scoliodon), Amphibia (Frog), Reptilia (Varanus), Aves (Pigeon), and Mammalia (Rabbit) **15 Lectures**

- **Integumentary System**: Structure and function of integument in vertebrates; Derivatives of Integumentary glands
- **Skeletal System**: Overview of the skeletal system; Brief account of jaw suspensorium and visceral arches
- **Digestive System:** Brief account of alimentary canal and digestive glands
- **Respiratory System:** Brief account of gills, lungs, air sacs and swim bladder

Unit –II

Comparative anatomy of mentioned vertebrates:

Pisces (Scoliodon), Amphibia (Frog), Reptilia (Varanus), Aves (Pigeon), and Mammalia (Rabbit)
15 Lectures

- **Circulatory System**: Evolution of the heart and aortic arches
- **Urinogenital System**: Succession of the kidney, Evolution of the urinogenital ducts
- **Nervous System**: Comparative anatomy of the brain
- **Sense Organs**: Types of receptors, visual receptors in man

Unit -III

History and Early Developmental Biology **04 Lectures**

- Scope and History of Developmental Biology; Concepts of Epigenesis, Preformation, Specification, Determination, Differentiation
- Differentiation, Competence, and Embryonic Induction.

Early Embryonic Development **15 Lectures**

- Gametogenesis: Spermatogenesis and Oogenesis in Mammals
- Parthenogenesis: Definition, types and mechanism
- Fertilization: Definition, Types (External and Internal), and mechanism of fertilization, blocking mechanism to polyspermy
- Cleavage: Definition, types, planes and patterns of cleavage, Blastulation
- Gastrulation: Morphogenetic Movements; fate of germ layers
- Early development of Frog (up to gastrula) and chick (up to 96 hours)
-

Unit-IV

Late Developmental Biology **15 Lectures**

- Metamorphic events in life cycle of frog and its hormonal regulation Metamorphosis in the Frog and Its Hormonal Regulation
- Extra embryonic membranes in the chick
- Placenta: Definition, formation, types, and functions of the placenta**.**
- Applied Aspects of Developmental Biology: Stem cells, Cloning, Assisted Reproductive Techniques (ART)

Suggested Books and References –

1. **Kent, G. C., & Carr, R. K.** (2000). *Comparative Anatomy of the Vertebrates* (9th ed.). McGraw-Hill Companies.
2. **Kardong, K. V.** (2005). *Vertebrates: Comparative Anatomy, Function and Evolution* (4th ed.). McGraw-Hill Higher Education.
3. **Gilbert, S. F.** (2014). *Developmental Biology* (10th ed.). Sinauer Associates, Inc., Sunderland, Massachusetts, USA. ISBN: 9780878939787.
4. **Balinsky, B. I.** (2008). *An Introduction to Embryology*. International Thomson Computer Press.
5. **Weichert, C. K., & Presch, W.** (1970). *Elements of Chordate Anatomy*. Tata McGraw-Hill.
6. **Hildebrand, M., & Goslow, G. E.** (2001). *Analysis of Vertebrate Structure*. John Wiley & Sons.
7. **Wolpert, L., & Tickle, C.** (2011). *Principles of Developmental Biology* (4th ed.). Oxford University Press. ISBN: 9780198792918.
8. **Slack, J. M. W.** (2013). *Essential Developmental Biology* (3rd ed.). Wiley-Blackwell.
9. **Larsen, W. J.** (2021). *Human Embryology* (6th ed.). Elsevier. *(Good comparative insights for vertebrate development)*
10. **Gilbert, S. F., & Barresi, M. J. F.** (2016). *Developmental Biology* (11th ed.). Sinauer Associates.
11. **Hall, B. K.** (1999). *Evolutionary Developmental Biology* (2nd ed.). Springer.
12. **Verma, P. S., & Agarwal, V. K.** (2018). *Cell Biology, Genetics, Molecular Biology, Evolution and Ecology* (Relevant embryology sections). S. Chand Publications, New Delhi.
13. **Arora, M. P., & Malhotra, P.** (2012). *Developmental Biology*. Himalaya Publishing House, Mumbai.
14. **Gupta, P. K.** (2015). *Cytology, Genetics, Evolution, and Ecology* (Developmental biology chapters). Rastogi Publications, Meerut.
15. **Khanna, D. R.** (2008). *Developmental Biology*. Discovery Publishing House, New Delhi.

Practical Books:

1. Ekambaranatha Ayyar, C. N., & Ananthakrishnan, T. N. – *Manual of Zoology, Vol. 2 (Chordates)*, S. Viswanathan (Printers & Publishers) Pvt. Ltd., Chennai.
2. Kotpal, R. L. – *Modern Textbook of Zoology – Vertebrates*, Rastogi Publications, Meerut.
3. Verma, P. S., & Agarwal, V. K. – *Cell Biology, Genetics, Molecular Biology, Evolution and Ecology*, S. Chand Publications, New Delhi.
4. Khanna, D. R. – *Biology of Chordates*, Discovery Publishing House, New Delhi.
5. Arora, M. P., & Malhotra, P. – *Developmental Biology*, Himalaya Publishing House, Mumbai.
6. Saxena, R. K., & Saxena, S. – *Vertebrate Zoology*, Viva Books Pvt. Ltd., New Delhi.

Suggested E-resources –

1. http://courses.missouristate.edu/dennishughes/Comparative%20Vertebrate%20Anato my.htm
2. Respiratory System - Encyclopedia Britannica https://www.britannica.com/science/respiratory-system-anatomy-and-physiology
3. Development and Evolution of the Heart - Nature https://www.nature.com/scitable/topicpage/development-and-evolution-of-the-heart- 24792709/
4. Comparative Anatomy of the Nervous System - Wiley Online Library https://onlinelibrary.wiley.com/doi/full/10.1002/cphy.c090036
5. Developmental Biology - Stanford University https://web.stanford.edu/group/Urchin/biolreprodsite/Development.html

Course Learning Outcome:

Upon completion of the course, students will be able to:

- Know about the levels of organization among different groups of vertebrates.
- Understand that different organs and organ systems integrate with each other to impart proper regulation of a particular function.
- Understand how the various organs evolved during the course of evolution through succession. Know the evolution of different concepts in developmental biology.
- Be able to understand the process of gamete formation from stem cell population to mature ova and sperm.
- Be able to comprehend the sequence of steps leading to the formation of gametes and
- Development of embryo.

- Learn the mechanisms underpinning cellular diversity and specificity in animals
- Study the methods and tools related to developmental biology which help to understand different processes of embryogenesis.

Practical based on Comparative Anatomy & Developmental Biology of Vertebrates

Duration: 4 Hrs

Max. Marks: 20+30 Marks

I. Osteology: **Frog, Varanus, Fowl, and Rabbit**

- Frog: Skull, Vertebral Column, Ribs, Sternum, Appendicular Skeleton (Bones of Forelimb and Hind Limb)
- Varanus: Skull, vertebral column, ribs, sternum, appendicular skeleton (Bones of Forelimb and Hind Limb)
- Fowl: Skull, vertebral column, ribs, fercula, appendicular skeleton (Bones of Forelimb and Hind Limb)
- Rabbit: Skull, vertebral column, ribs, sternum, appendicular skeleton (Bones of Forelimb and Hind Limb)

II. Anatomy (Labeo /Wallago)

- Study of afferent and efferent branchial blood vessels
- Eye Muscles and Innervations: Analysis of the eye muscles
- Brain, cranial nerves (identification of cranial nerves), Internal Ear

III. Study of the following through Permanent Slide preparations:

- Striped muscle fibers; Smooth muscle fibers, scales of Wallago/ Labeo, feathers of birds, hair of different animals, blood film of any vertebrate

IV. Exercises on Developmental Biology

Study of Frog Development:

- Whole Mounts, and Sections Through Permanent Slides - Cleavage Stages, Blastula, Gastrula, Neurula, Tail Bud Stage, Tadpole External and Internal Gill Stages.

Study of Chick Embryo:

- Chick Embryo:18 Hrs, 21 Hrs, 24 Hrs, 33 Hrs, 48 Hrs, 72 Hrs, and 96 Hrs of Incubation.
- Study of the Embryo at Various Stages of Incubation in vivo by Making a Window in the Egg-Shell
- Blastoderm mounting of chick embryo

Scheme of Practical Examination and Distribution of Marks

S.N.	Exercise/Practical	Regular	Ex. Students
1.	Major Exercise	**3**	**12**
2.	Minor Exercise/ Mounting	**2**	**6**
3.	Developmental Biology	**3**	**6**
4.	Identification and comments on Spots (1 to 6)	**12**	**16**
5.	Viva Voce	**5**	**10**
6.	Class Record	**5**	
	Total	**30+20*=50**	**50**

*Internal marks for regular students only

Note:

1. With reference to microscopic slides, in case of non-availability, the exercise should be substituted with diagrams / photographs.
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